BLACKSTONE RIVER FLOOD CONTROL

LOWER WOONSOCKET

LOCAL PROTECTION PROJECT

DRAINAGE STUDY - SOCIAL DISTRICT PUMPING STATION AREA

CHARLES A. MAGUIRE & ASSOCIATES
ENGINEERS
PROVIDENCE - BOSTON - HARTFORD

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April 19, 1962

REPLY TO: Providence

Division Engineer
U. S. Army Engineer Division
New England
Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Attention: Mr. Edwin F. Coffin, Project Engineer

Re: Contract No. DA-19-016-CIVENG-62-224
Drainage Study - Social District
Line Item No. 2 - Lower W oonsocket
Local Protection Project
Woonsocket, Rhode Island

Dear Sir:

In accordance with our contract agreement dated 12 March 1962, we have prosecuted a study of the interior drainage area to be served by the Social District pumping station.

This report is based on data recorded by field reconnaissance to establish the limits of the natural drainage area. In addition, data available from city records were supplemented by field reconnaissance to establish the extent of the existing storm drainage system. This investigation included the establishment of the principal storm drains which will require interception for discharge to the pumping station. Data were recorded as to pipe types, sizes, grades and pipe capacities were estimated. In addition, investigations were made to determine the drainage contribution originating outside the natural drainage area. The results are included in tabular form and the data are also presented on a plan of the drainage system to permit checking of any individual component of the system.

This investigation included the establishment of those storm drains which reduce the natural runoff of the drainage area by virtue of discharging outside of the natural drainage area.

The runoff factors for divisional portions of the natural drainage area were established by field reconnaissance and the accompanying text and data substantiate the reasons for the appropriate selections.

Very truly yours,

CHARLES A. MAGUIRE & ASSOCIATES

F. C. Pierce

GENERAL - As part of the construction of the flood control project in the lower section of the City of Woonsocket, referred to as the Social District in the Interim Report dated May 29, 1957, a series of dikes and flood walls will be built along the north bank of the Blackstone River. The Mill and Peters Rivers in this area will also be enclosed in a combination of pressure conduits, dikes and flood walls. Because of this work, a substantial portion of the interior drainage will be trapped during high stages of the rivers.

The following study of the interior drainage area and its particular features has been instituted for use in the determination of the capacity of the pumping station, probable ponding areas, and possible inundation elevations behind the protective works during storms of various magnitudes.

DESCRIPTION OF STUDY AREA - Most of the area to be protected by the construction of the flood control project consists of a very highly concentrated business and residential section adjacent to the low-lying land along the Mill and Peters Rivers and the left bank of the Blackstone River. The one undeveloped section between Clinton Street, the Social Tailrace and the Blackstone River has a new bowling alley building and parking area currently under construction on it and will probably be fully developed when the flood works are completed. Therefore, it is safe to assume that the total area to be protected will be a homogenous section of concentrated business and tenement buildings with many paved parking areas and drives.

The section to be protected constitutes about one-third of the total drainage area. However, the runoff from approximately two-thirds of the drainage area will also have to be intercepted and pumped or stored behind the protective works during storms occurring when the three rivers are in the flood stage.

TOPOGRAPHY - The total contributing drainage area within this district is about 295 acres, of which some 60 to 65 acres can easily be altered to discharge outside of the protected area. The southerly or lower area adjacent to the left bank of the Blackstone River and the Mill and Peters Rivers is a very heavily built-up business and residential section, fairly flat with many paved parking areas and drives. What little soil that is exposed is sandy in character. There is practically no ground cover in this area. The northwesterly area of the district is made up of a closely built-up residential and business area with some sparse ground cover in the upper sections and practically none in the lower section. The area between the Mill and Peters Rivers consists of a concentrated business and tenement area in the lower and middle section with practically no ground cover and a cemetery with grass and wooded slopes in the upper portion. The area to the west of the Peters River is also a highly concentrated residential area with some businesses along Cumberland Street and practically no ground cover.

The only appreciable areas left to develop are a small area along the left bank of the Blackstone River and a small area between Social Street, Memorial Pond and the Mill River.

EXISTING DRAINAGE SYSTEM - The existing drainage system consists of several major lines and numerous short-run minor lines. The runoff from the area between Summer, Rebekah and North Main Streets (Area 1A, Plate A4) collects in a series of side streets and flows into North Main Street, where it is intercepted by a group of curb inlets at the intersection of East School Street and North Main Street. It then flows down North Main Street in a 24-inch vitrified clay pipe to just past the railroad and then continues in an 18-inch vitrified clay pipe to Pond Street. The runoff from the area adjacent and to the west of Pond Street (Area 1B, Plate A4) is intercepted by a series of catch basins with curb inlets and grates and is collected in an 18-inch vitrified clay line that extends down to East School Street, where it joins the 18-inch vitrified clay line from North Main Street. It then continues down East School Street in an 18-inch, then 24-inch vitrified clay line to the vicinity of the intake structure to Memorial Pond. The flow then passes down the street to the Mill River in a 24-inch reinforced concrete pipe and empties into the river on the northerly side of East School Street. Easterly from the river along East School Street (Area 6, Plate A4) a 15-inch vitrified clay line extends to the intersection of Ives Street, where it intercepts a 12-inch line from Hazel Street. The 15-inch vitrified clay line then continues down Ives Street and into the Mill River. The drainage in this line is picked up in a series of curb inlets along East School Street and at the intersection of Hazel and Ives Streets. Part of the area adjacent to Rathbun Street (Area 7, Plate A4) flows into Rathbun Street and down the street to a group of curb inlets at the intersection of East School Street and Rathbun Streets. A 15-inch vitrified clay line extends up East School Street and down Elbow Street to discharge into the Mill River. Curb inlets along East School Street collect the runoff and discharge into this line. A 15-inch vitrified clay line in Social Street beginning at George Street extends down the street to Chester Street, where the line increases to a 20-inch vitrified clay line which continues to Elm Street. At Elm Street it increases to a 24-inch vitrified clay line and continues down the street to discharge into the Peters River. A series of curb inlets along Social Street and Elm Street intercept the runoff from this area (Area 8, Plate A4). The drainage from the area above Spring and Prospect Streets (Area 2A, Plate A4) flows down the two streets and is collected by a group of four curb inlets at the intersection of the two streets. From this intersection it flows down Prospect Street in a 15-inch vitrified clay line to Summer Street, where it increases in size to an 18-inch vitrified clay line. The 18-inch line then continues down past West School Street and under the railroad to a manhole in North Main Street at the upper part of the second half of the drainage area (Area 2B, Plate A4). A 15-inch vitrified clay line also flows into this manhole from just over the railroad tracks on North Main Street. At the manhole the line increases to a 20-inch vitrified clay line and continues in this size to Daniels Street, where it becomes a

27-inch vitrified clay line to Snow Street and all the way down Snow Street to Pond Street. Curb inlets at strategic points intercept the runoff and discharge it into these lines. A 15-inch vitrified clay line extends down Blackstone and Corey Streets to North Main Street and then up North Main Street in an 18-inch vitrified clay line to the manhole at the intersection of North Main Street and Snow Street. At the corner of Snow and Pond Streets a 15-inch vitrified clay line that starts at Daniels Street and extends down Pond Street is intercepted by the manhole at the intersection. At this point the trunk line increases to a 30-inch vitrified clay pipe and continues to the end of Snow Street near the pond with a very flat slope. At the pond the line changes to a 24-inch concrete pipe which continues around the pond to the far side, where it increases to a 30-inch concrete pipe at a catch basin. From the catch basin the 30-inch line continues to the outlet structure for the pond, where it discharges into the Mill River. The rest of the drainage area around the pond (Area 3, Plate A4) is intercepted by catch basins and is discharged into the Mill River near the East School Street substation. At the intersection of Pond and Social Streets (Area 4A, Plate A4) a 15-inch vitrified clay line begins and then extends down Social Street all the way to Gobeille Street, where it discharges into the old Social Tailrace in an 18-inch vitrified clay line. A series of curb inlets at the side streets intercepts the water along this line. At the intersection of Worrall Street and Federal Street (Area 4B,

Plate A4) a group of five curb inlets intercepts the runoff from this area and discharges it into an 18-inch vitrified clay line that extends down Worrall Street to Clinton Street. At this point it increases to a 24-inch vitrified clay line that continues all the way to and discharges into the old Social Tailrace. A series of curb inlets at the intersection of the side streets collects the flow that this line carries. At the intersection of Wood and Elm Streets (Area 13, Plate A4) a 12-inch vitrified clay line extends all the way to the Peters River with a series of curb inlets intercepting the gutter flow. A 15-inch vitrified clay line from Robinson Street also ties into the 12-inch line before it discharges into the river. A 15-inch vitrified clay line starts in Godfrey Street and runs to Brook Street (Area 11, Plate A4). At this point it increases to a 21-inch vitrified clay line that extends to the intersection of Brook and Cumberland Streets, where it increases to a 24-inch vitrified clay line which runs to and down Clinton Street and discharges into the Mill River. The other drainage areas (Areas 5, 9, 10 and 12, Plate A4) have some local curb inlets and short-run pipes to the river.

The critical feature of the closed drainage system is the ability of the standard curb inlet to intercept the gutter flows. Although some areas are bracketed quite well with inlets, others do not have nearly enough openings, and therefore there will be a portion of the runoff that will bypass the inlets.

CAPACITY OF THE EXISTING STORM DRAINAGE SYSTEM - Theoretical capacities of the existing storm drain lines were determined for the pipes flowing full at their given slope. The "n" value used in the Manning Formula was .013 for the vitrified clay pipe and the concrete pipe. An "n" value of .015 was used for the calculation of flows in the gutters in the formula $Q = .56 \left(\frac{Z}{n}\right) s^{1/2} y^{8/3}$ for the determination of the depth of flow in gutters. In some cases the fairly steep slopes of the pipes gave a large theoretical value of the quantity of storm water the pipes can carry. In these cases an analysis was made to determine what a logical flow would be in these pipes. As the average manhole is about 6 feet to 7 feet deep, it was felt that a 3-foot surcharge on the outlet pipe could be obtained and not cause any trouble. Table 2 shows the theoretical entrance capacity of the pipes under various surcharges and the estimated maximum flow capacity of the various pipe sizes. The values of the theoretical maximum flow capacity of the pipes flowing full and the estimated practical capacity are shown on Plate A4 adjacent to the applicable line.

Except for the upper portion of Pond Street, where curb inlets with "D" type grates are used, the standard Woonsocket curb inlet type catch basin with no grate is used. The curb inlet openings are about 4 feet long with a 4-inch to 8-inch high opening. Most of the curb inlets have a depressed gutter in front of them with an average depression of about 0.3 of a foot. By use of charts developed by the Bureau of Public

Roads (Plate A-1) a graph of gutter flow versus percent intercepted by curb inlet at various gutter slopes with a constant cross slope of 3/8 inch per foot was plotted. It can be seen that for any appreciable flows on the steeper grades, it is possible for a considerable portion of the flow to bypass the inlet.

STORM RUNOFF - Storm runoff was calculated for each of the individual drainage areas and for the total drainage area involved in this study. Drainage areas were determined from field reconnaissance and aerial photogrammetric sheets. Values of coefficients were determined by field reconnaissance and experience as were estimates of concentration times.

The rainfall intensity - duration relationships were developed by interpolating the values given in "Technical Paper No. 40 - Rainfall Frequency Atlas of the United States", published in May 1961 by the United States Department of Commerce. (Table 3 and Plate A-4.)

The values obtained from this information agree very closely with those developed by David Yarnell in United States Department of Agriculture Publication No. 204.

The storm water runoff was determined by the use of the Rational Formula Q = C I A.

Q = Runoff - peak discharge of watershed in cubic feet per second.

C = Coefficient of runoff.

I = Maximum average rainfall intensity in inches per hour based on concentration time.

A = Area in acres.

The values of C were estimated by evaluating the slope, type of area, degree of saturation, compaction, surface irregularity, character of subsoil, and possible build-up of the area studied. The "C" value was further altered with the frequency of the storm. A higher "C" value was used for the more intense storms. Consideration was given to detention and storage on flat roofs, unpaved and paved surfaces. No estimate was made for ponding in the upper area. The only substantial ponding that will occur is in that portion of the Mill and Peters Rivers that will be left intact after the construction of the dikes and pressure conduits and in Memorial Pond. However, due to the fact that there would be some danger of pollution if Memorial Pond was used as a storage area, it was felt that it would be best to neglect it. However, a detailed study of the Memorial Pond is the subject of another report and this point will be developed further.

Storms of 2-year, 5-year, 10-year, 25-year and 50-year frequency were studied. The estimated values of "C" and runoff for the various areas under the five storm conditions are shown in Table 1.

CONTRIBUTIONS FROM OUTSIDE OF THE NATURAL DRAINAGE AREA - An analysis of the total Social District area indicates that there is no significant contribution of storm water runoff from outside of the natural drainage area.

REDUCTION OF NATURAL RUNOFF - Investigation of the existing storm drains indicates the following possibilities for reducing the runoff into the protected area:

(1) The 18-inch and 24-inch lines in East School Street in the vicinity of Memorial Pond carrying the runoff from drainage areas 1A and 1B (Plate A-4) could be increased in size and laid as a pressure conduit to discharge into the Mill River. With the addition of several new inlets in the upper section of East School Street to insure that most of the runoff is intercepted, anywhere from 20 to 40 cubic feet per second could be excluded from the protected area.

(2) The 12-inch line running northwesterly down Elm Street from Wood Street that discharges into the Peters River could be increased to an 18-inch line at the intersection of the 15-inch line from Robinson Street and run as a pressure main to discharge just above the proposed pressure box culvert that carries the Peters River. With the addition of two catch basins most of the runoff from area 13 (Plate A-4) could be excluded from the protected area.

(3) The 24-inch line running southeasterly along Elm Street from Social Street to the Peters River could be handled in a similar manner. If the line from the intersection of Social Street and Elm Street is relaid as a pressure conduit to above the proposed pressure box culvert carrying the Peters River, about 20 cubic feet per second from area 8 (Plate A-4) could be excluded from the protected area. It would also be possible to bypass a good portion of drainage areas 2A and 2B (Plate A-4). By intercepting the trunk line somewhere on Snow Street, depending on the high water elevation, and rerouting the line down the existing streets to the Blackstone River, we could exclude most of the area.

However, from 2,000 to 2,500 feet of large diameter pipe would have to be laid in existing city streets. At this early stage in the analysis it would seem that it would not be economically justified to do this.

All of the other areas will have to be intercepted and brought into the pumping station by use of the existing channels that are to be abandoned, new drainage lines, and/or new ditches.

Area No.	Acres	Frequency (Years)	Conc. Time	Rainfall In/Hr	C	Runoff c.f.s.
1A	21.4	2	26 min.	1.80	.45	17.3
		5		2.53	.48	26.0
		10		3.32	.50	35.5
		25		3.85	.55	44.3
		50		4.25	.60	54.5
1B	13.4	2	17 min.	2.28	.40	9.1
		5		3.22	.43	18.6
		10		4.10	.45	24.7
		25		4.70	.50	31.5
		50		5.35	.55	49.4
1A and 1B	34.8	2	27 min.	1.75	.43	26.2
		5		2.48	.46	39.7
		10		3.20	.48	53.5
		25		3.70	.53	68.0
		50		4.20	.58	84.8
2A	18	2	24.5 min.	1.90	.45	15.4
		5		2.68	.48	23.2
		10		3.45	.50	31.1
		25		4.00	.55	39.6
		50		4.50	.60	48.5
2B	41	2	23 min.	1.92	.50	39.4
		5		2.71	.53	58.9
		10		3.50	.55	79.0
		25		4.05	.60	100.0
		50		4.50	.65	120.0
2A and 2B	59	2	29.5 min.	1.67	.48	47.3
		5		2.32	.51	69.8
		10		3.04	.53	95.0
		25		3.50	.58	120.0
		50		3.98	.63	148.0

TABLE 1

RUNOFF

Area No.	Acres	Frequency (Years)	Conc. Time	Rainfall In/Hr	C	Runoff c.f.s.
3	13.2	Area around Memorial Pond excluding the pond.				
		2	20 min.	2.10	.30	8.3
		5		2.95	.33	12.9
		10		3.77	.35	17.4
		25		4.35	.40	23.0
		50		4.90	.45	29.1
4A	10.6	2	16 min.	2.35	.60	14.9
		5		3.33	.63	22.2
		10		4.25	.65	29.3
		25		4.85	.70	35.9
		50		5.50	.75	44.5
4B	23.5	2	15.3 min.	2.42	.60	22.6
		5		3.42	.63	50.6
		10		4.40	.65	67.2
		25		5.00	.70	82.2
		50		5.60	.75	98.5
6	27.1	2	29 min.	1.67	.35	15.8
		5		2.38	.38	24.5
		10		3.08	.40	33.4
		25		3.55	.45	43.3
		50		4.00	.50	54.2
7	20.6	2	28 min.	1.71	.45	15.8
		5		2.42	.48	23.9
		10		3.12	.50	32.1
		25		3.62	.55	41.0
		50		4.05	.60	50.0
8	16.9	2	14.5 min.	2.50	.50	21.1
		5		3.50	.53	31.4
		10		4.40	.55	40.8
		25		5.00	.60	50.7
		50		5.85	.65	64.2

TABLE 1
(CONTINUED)

RUNOFF

Area No.	Acres	Frequency (Years)	Conc. Time	Rainfall In/Hr	C	Runoff c.f.s.
9	14.3	2	21 min.	2.03	.50	11.6
		5		2.88	.53	21.8
		10		3.68	.55	29.0
		25		4.24	.60	36.4
		50		4.80	.65	44.7
10	11.0	2	14 min.	2.51	.60	16.5
		5		3.58	.63	24.8
		10		4.50	.65	32.2
		25		5.15	.70	39.7
		50		5.80	.75	47.8
11	9.7	2	14.5 min.	2.50	.60	14.5
		5		3.50	.63	21.4
		10		4.40	.65	27.7
		25		5.00	.70	34.0
		50		5.85	.75	42.7
12	18.0	2	15.7 min.	2.38	.50	21.4
		5		3.38	.53	32.2
		10		4.25	.55	42.2
		25		4.90	.60	53.0
		50		5.50	.65	64.3
13	10.7	2	19 min.	2.15	.45	10.3
		5		3.03	.48	15.6
		10		3.88	.50	20.8
		25		4.45	.55	26.2
		50		5.05	.60	32.4
Total Area excluding 1A, 1B, 8 and 13	220.9	2	34.7 min.	1.40	.48	149
		5		1.96	.51	221
		10		2.53	.53	296
		25		2.92	.58	374
		50		3.65	.63	507

TABLE 1
(CONTINUED)

RUNOFF

Entrance Capacity of Pipe Culverts (Neglecting Velocity of Approach)

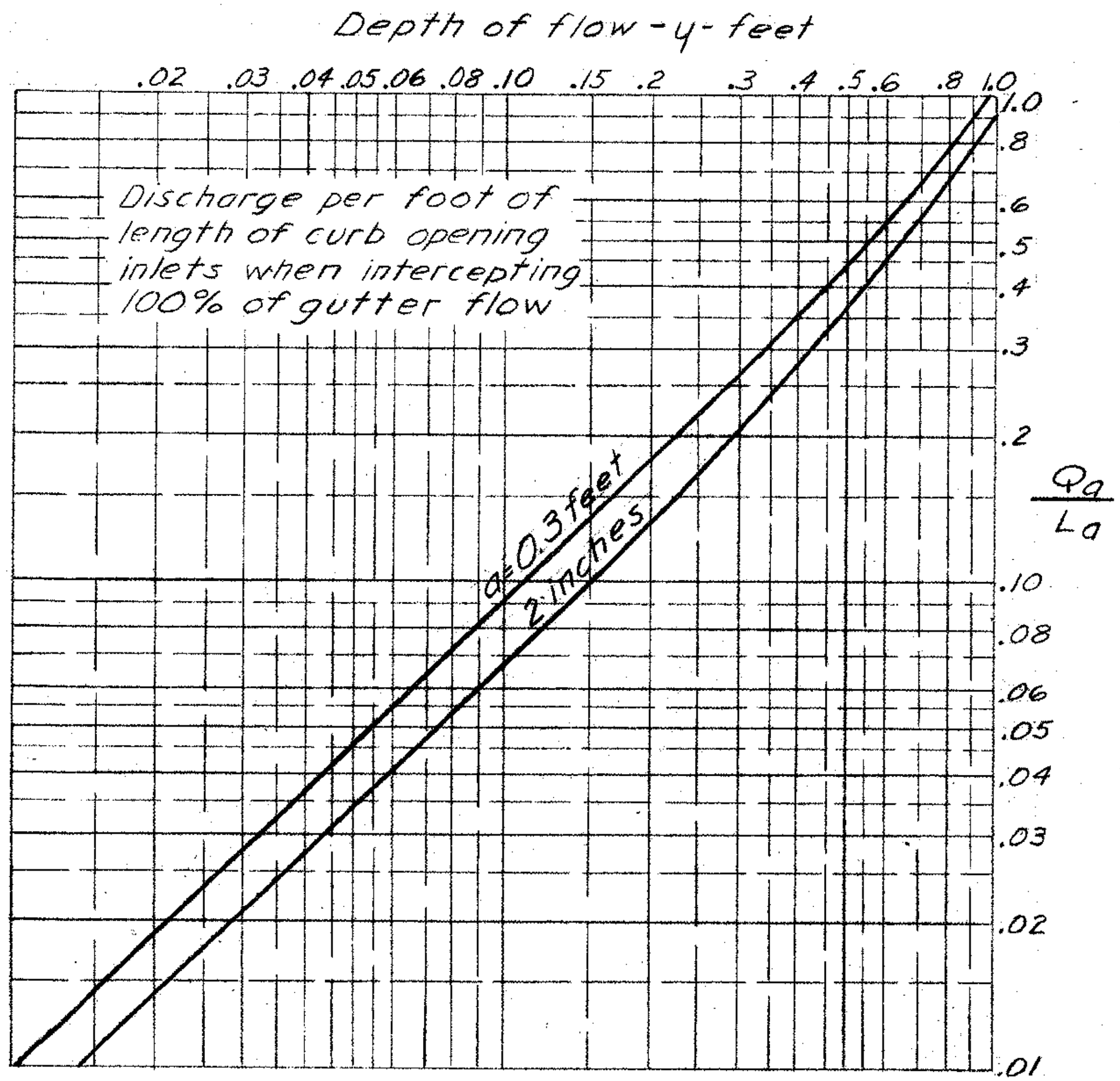
Pipe Size	Surcharge	Capacity in c.f.s.	Estimated Max. Value to be used assuming 3' of surcharge
12"	0	2.2	
	1	4.6	
	2	6.0	
	3	7.3	7.3 c.f.s.
15"	0	3.6	
	1	7.3	
	2	9.5	
	3	11.25	11 c.f.s.
18"	0	5.9	
	1	11.0	
	2	14.0	
	3	17.0	17 c.f.s.
20"	0	8.0	
	1	14.0	
	2	18.0	
	3	21.0	21 c.f.s.
21"	0	8.8	
	1	15.5	
	2	19.5	
	3	23.0	23 c.f.s.
24"	0	12.5	
	1	20.0	
	2	27.0	
	3	31.0	
	4	35.0	31 c.f.s.
27"	0	15.5	
	1	26.0	
	2	33.0	
	3	38.0	
	4	43.0	38 c.f.s.
30"	0	21.0	
	1	34.0	
	2	43.0	
	3	48.0	
	4	56.0	48 c.f.s.

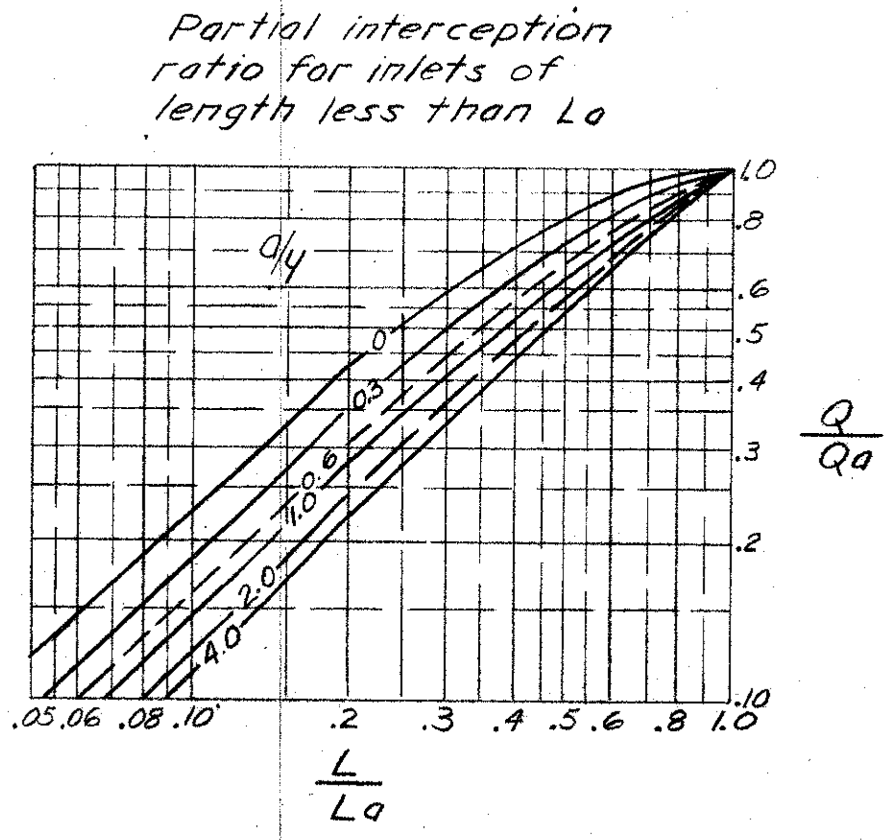
TABLE 2

RAINFALL AND RAINFALL RATES FOR PLOTTING
THE RAINFALL INTENSITY-DURATION-FREQUENCY CURVES
FOR THE WOONSOCKET, RHODE ISLAND AREA

Time	2 yr. Rainfall	2 yr. Rate	5 yr. Rainfall	5 yr. Rate	10 yr. Rainfall	10 yr. Rate	25 yr. Rainfall	25 yr. Rate	50 yr. Rainfall	50 yr. Rate
5 min.	.32	3.84	.46	5.51	.56	6.75	.64	7.70	.72	8.62
10 min.	.49	2.94	.71	4.26	.86	5.16	.99	5.95	1.11	6.66
15 min.	.62	2.48	.90	3.60	1.08	4.32	1.25	5.00	1.40	5.60
30 min.	.85	1.70	1.25	2.50	1.50	3.00	1.73	3.46	1.94	3.98
1 hr.	1.06	1.06	1.52	1.52	1.92	1.92	2.16	2.16	2.50	2.50
2 hr.	1.37	.68	1.97	.98	2.40	1.20	2.85	1.42	3.15	1.58
3 hr.	1.54	.51	2.30	.73	2.75	.92	3.10	1.03	3.46	1.15
6 hr.	1.98	.33	2.78	.46	3.35	.56	3.90	.65	4.25	.71
12 hr.	2.38	.20	3.31	.28	4.00	.33	4.70	.39	5.20	.43
24 hr.	2.85	.12	4.03	.17	4.75	.20	5.5	.23	6.3	.26

TABLE 3





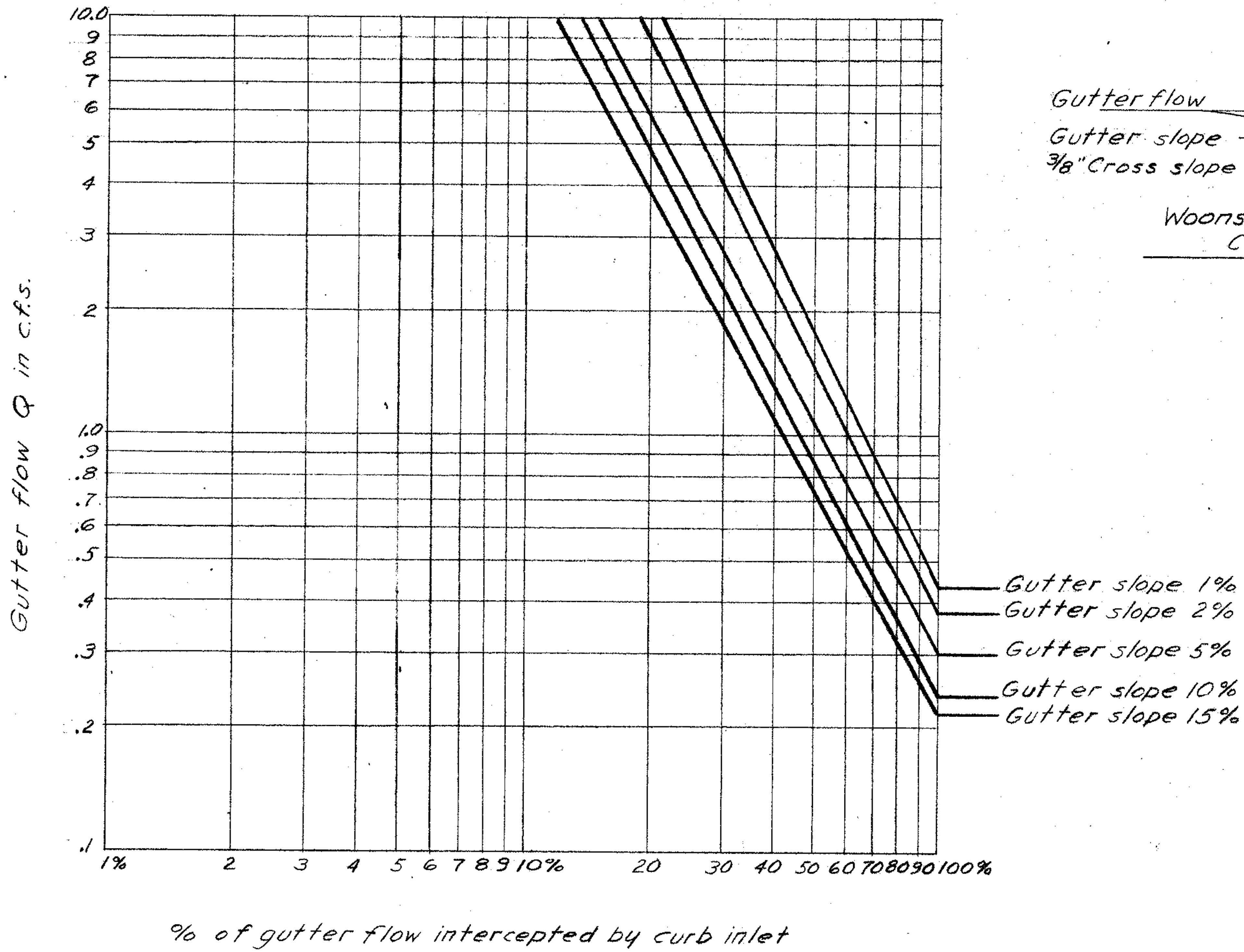
Charts from Bureau of Public Roads

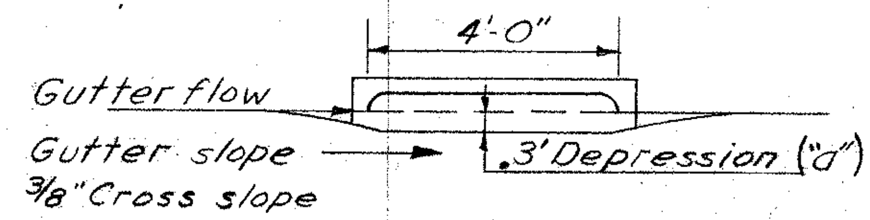
BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

CAPACITY OF CURB OPENING INLETS ON CONTINUOUS GRADES

CHARLES A. MAGUIRE & ASSOCIATES
APRIL, 1962

PLATE A-1





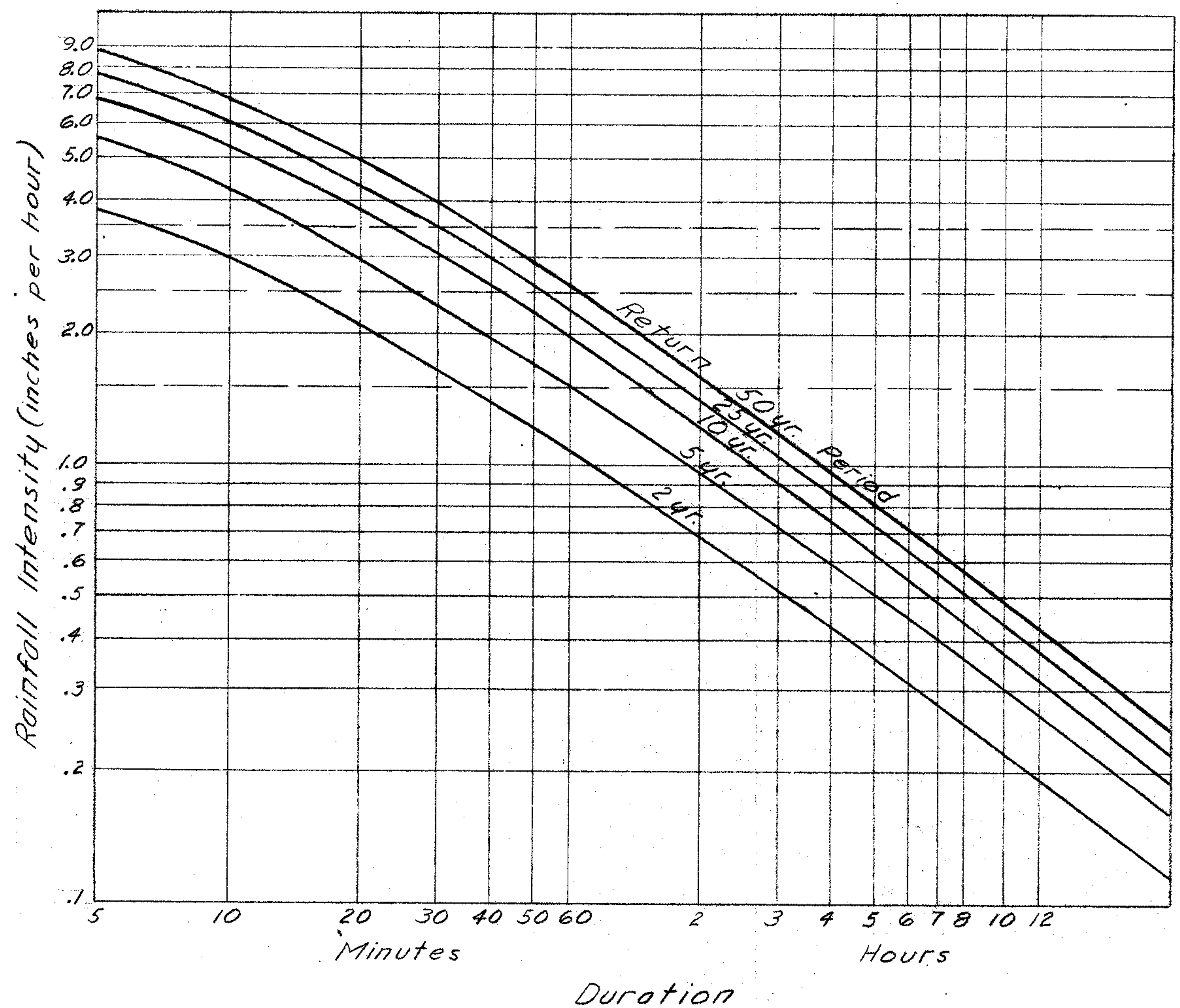
Woonsocket Standard Curb Inlet

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

CAPACITY OF WOONSOCKET STANDARD CURB INLET

CHARLES A. MAGUIRE & ASSOCIATES
APRIL, 1962

PLATE A-2

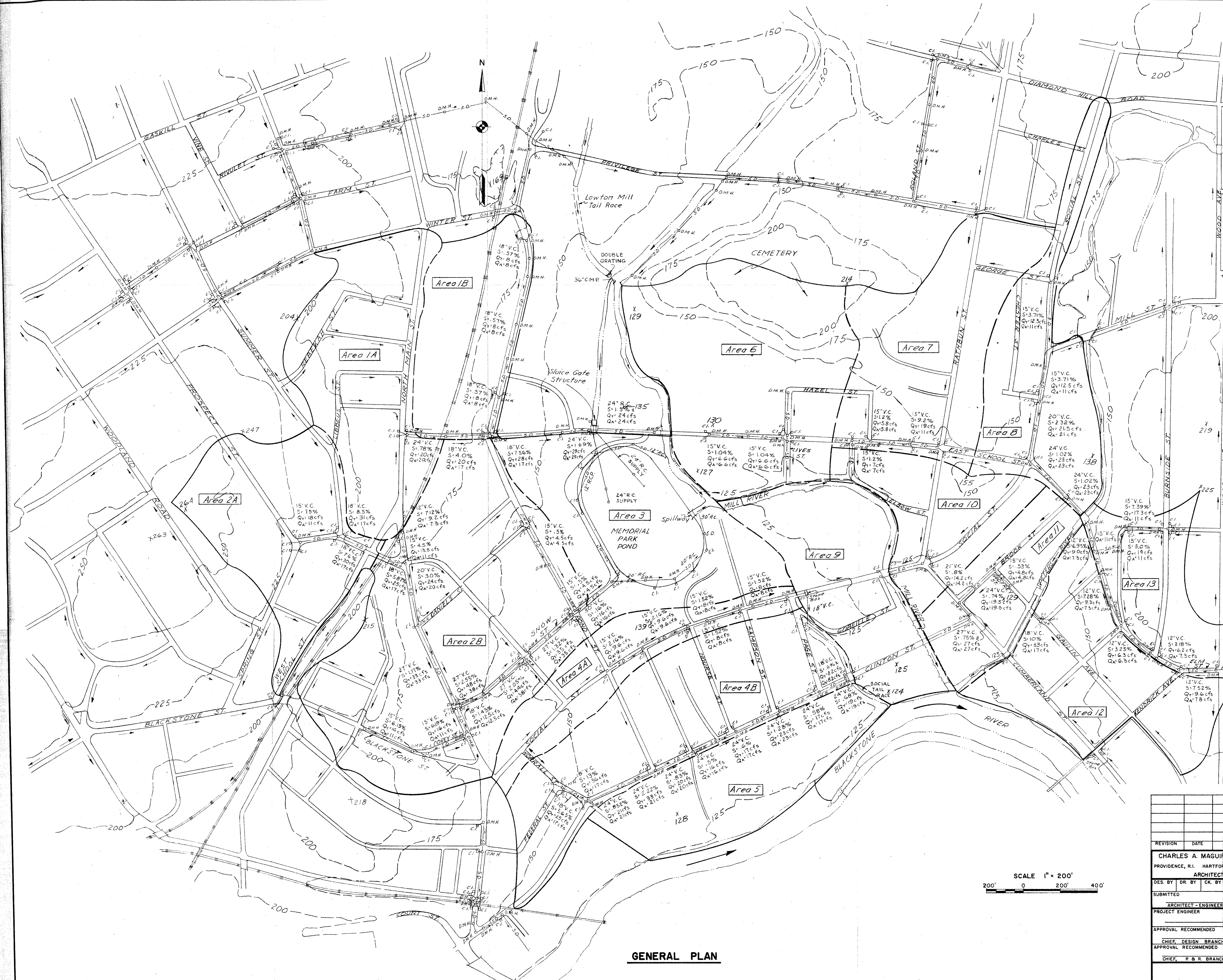


BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

RAINFALL INTENSITY – DURATION FREQUENCY CURVES FOR WOONSOCKET

CHARLES A. MAGUIRE & ASSOCIATES
APRIL, 1962

PLATE A-3



Legend:

- □ D.M.H. Storm Drain Manhole
- □ C.I. Catch Basin or Curb Inlet
- —S.D.→ Storm Drain Line with Flow Arrow
- ——— Outline of Total Drainage Area
- — — — Outline of Sub-Drainage Area
- ←— —→ Surface Water Flow Directions in Gutters

Notes:

1. Q_T value shown is theoretical capacity of storm drain flowing full at the given slope.
2. Q_A value shown is estimated maximum flow in storm drain assuming a 3' surcharge as a maximum.
3. 25 foot contours and spot grades are approximate and are shown for informational purposes only.
4. Storm drains outside of the drainage area are shown for informational purposes only.

Area No.	Area in Acres	Coeff.
1A	21.4	.45 to .60
1B	13.4	.40 to .55
2A	18.0	.45 to .60
2B	58.8	.50 to .65
3	8.8	.30 to .45
4A	10.6	.60 to .75
4B	23.5	.60 to .75
5	14.9	.65 to .80
6	27.1	.35 to .50
7	20.6	.45 to .60
8	16.9	.50 to .65
9	14.3	.50 to .65
10	11.0	.60 to .75
11	9.7	.60 to .75
12	18.0	.50 to .65
13	10.7	.45 to .60

REVISION	DATE	DESCRIPTION	BY

CHARLES A. MAGUIRE & ASSOCIATES
PROVIDENCE, R.I. HARTFORD, CONN. BOSTON, MASS.
ARCHITECT-ENGINEER

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY

SUBMITTED
ARCHITECT-ENGINEER

PROJECT ENGINEER

APPROVAL RECOMMENDED
CHIEF, DESIGN BRANCH

APPROVAL RECOMMENDED
CHIEF, P & R. BRANCH

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
SOCIAL DISTRICT DRAINAGE STUDY
GENERAL PLAN

BLACKSTONE RIVER RHODE ISLAND

APPROVED
CHIEF, ENGINEERING DIVISION
DATE

SCALE | SPEC. NO.
DRAWING NUMBER
SHEET